(12) INTERNATIONAL APPLICATION PUBLISHED UNDER THE PATENT COOPERATION TREATY (PCT)

(19) World Intellectual Property Organization
International Bureau

(43) International Publication Date
15 January 2004 (15.01.2004)

PCT

(10) International Publication Number
WO 2004/005670 A1

(51) International Patent Classification[7]: E21B 43/12, 43/34, 43/40

(21) International Application Number: PCT/US2003/021487

(22) International Filing Date: 9 July 2003 (09.07.2003)

(25) Filing Language: English

(26) Publication Language: English

(30) Priority Data:
10/192,784 10 July 2002 (10.07.2002) US

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(81) Designated States (*national*): AE, AG, AL, AM, AT, AU, AZ, BA, BB, BG, BR, BY, BZ, CA, CH, CN, CO, CR, CU, CZ, DE, DK, DM, DZ, EC, EE, ES, FI, GB, GD, GE, GH, GM, HR, HU, ID, IL, IN, IS, JP, KE, KG, KP, KR, KZ, LC, LK, LR, LS, LT, LU, LV, MA, MD, MG, MK, MN, MW, MX, MZ, NI, NO, NZ, OM, PH, PL, PT, RO, RU, SC, SD, SE, SG, SK, SL, TJ, TM, TN, TR, TT, TZ, UA, UG, UZ, VC, VN, YU, ZA, ZM, ZW.

(84) Designated States (*regional*): ARIPO patent (GH, GM, KE, LS, MW, MZ, SD, SL, SZ, TZ, UG, ZM, ZW), Eurasian patent (AM, AZ, BY, KG, KZ, MD, RU, TJ, TM), European patent (AT, BE, BG, CH, CY, CZ, DE, DK, EE, ES, FI, FR, GB, GR, HU, IE, IT, LU, MC, NL, PT, SE, SI, SK, TR), OAPI patent (BF, BJ, CF, CG, CI, CM, GA, GN, GQ, GW, ML, MR, NE, SN, TD, TG).

Published:
— *with international search report*

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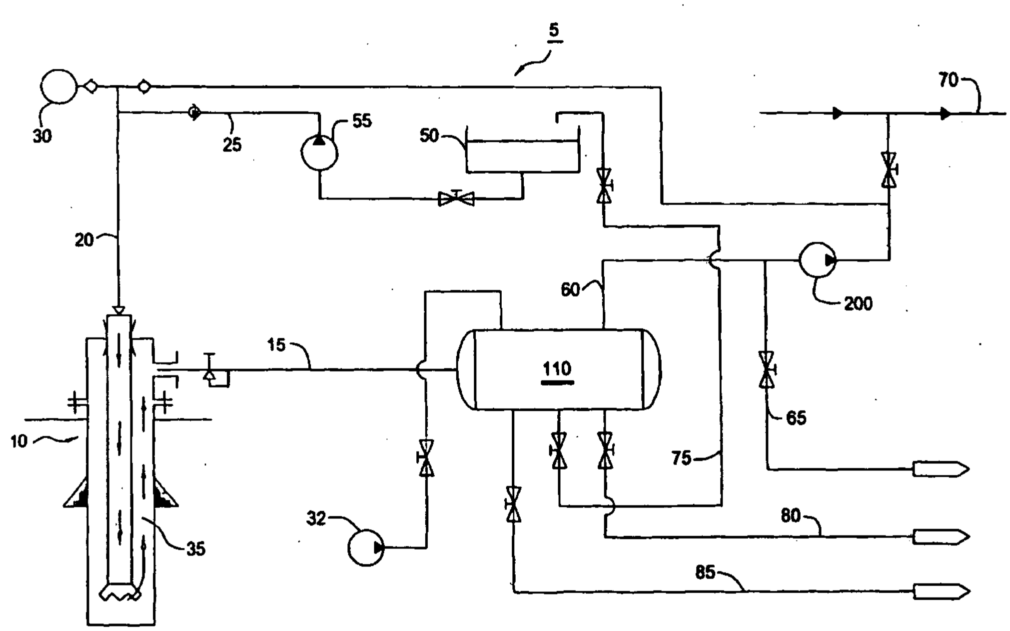
(54) Title: CLOSED LOOP MULTIPHASE UNDERBALANCED DRILLING PROCESS



(57) Abstract: The present invention provides apparatus and methods for handling fluids returning from a well. The fluids are introduced into a separator (110) and a separated gas stream (60) is recovered or recycled. The gas stream may comprise more than one phase. The separated gas stream is urged through a multiphase pump (200) before it is recovered. Alternatively, the return fluids may pass through a multiphase pump before it is introduced into the separator.

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second plunger 222 is moving in an opposite direction toward a retracted position. This causes the return fluid in the second plunger cavity to expel through an outlet 235. In this manner, the multiphase return fluid may be effectively moved to a separator 110. Although a pair of cylinders 211, 212 is disclosed, it is contemplated that the aspects of the present invention may be used with one cylinder or any number of cylinders.

Even though the wet gas contains three phases, the multiphase pump 200 may effectively increase the pressure of the wet gas in the wet gas line 60 and recycle the wet gas back to the well inlet 20. In this respect, the fluid handling circuit 5 according to aspects of the present invention may significantly reduce the requirements of separation equipment for recycling the wet gas. Moreover, the multiphase pump 200 will allow recovery or recycling of low pressure gas. In this manner, valuable return fluid gas such as nitrogen and natural gas may be recycled and/or recaptured.

The fluid handling circuit 5 may include a flare line 65 connected to the wet gas line 60. The flare line 65 may be used to discharge excess wet gas in the wet gas line 60. The flare line 65 may direct the excess wet gas to a flare stack or a collecting unit for other manners of disposal.

The oil contained in the return fluid is separated at the second stage. The separated oil collects in a tank (not shown) placed in the second stage of the separator 110. When the oil reaches a predetermined level in the tank, the oil is removed from the separator 110 through line 80. Typically, the oil is disposed in an oil tank for recovery.

Finally, liquid that is substantially free of oil collects in a chamber or reservoir (not shown). Typically, the liquid consists substantially of water. When the liquid reaches a predetermined level, it is discharged to the drilling fluid supply 50 through line 75. In this manner, the liquid may be recycled for use during the drilling operation. The circuit 5 may optionally include a secondary separator (not shown) to separate out any gas remaining in the liquid before delivering it to the drilling fluid supply 50. The separated gas may either be flared or delivered to the wet gas line 60 through a line

(not shown) connecting line 75 to line 60. From the drilling fluid supply 50, the liquid may be delivered to the well inlet 20 by a pump 55.

In another embodiment, an export line 70 may be connected to the wet gas line 60. When natural gas is used as the lightening gas or the drilling occurs in a producing formation, the wet gas leaving the separator 110 will contain valuable natural gas. The multiphase pump may be used to increase the wet gas pressure to that of the export line. Thereafter, the wet gas may be captured and realized by directing the gas stream to the export line 70. As a result, the well 10 may start producing for an operator even before the well 10 is completed.

In operation, the return fluid exiting the well outlet 15 enters the separator 110 for separation as shown in Figure 1. The return fluid is processed in the separator 110 to produce separate streams of solids, liquids, oil, and gas. The solids are removed from the separator 110 through line 85. The oil is removed from the separator 110 through line 80. The liquid is removed from the separator 110 through line 75 and delivered to the drilling fluid supply 50 for recycling. The gas is removed from the separator 110 through line 60. From there, the wet gas enters the multiphase pump 200 where its pressure is increased to facilitate transport through the system 5. Even though the wet gas contains more than one phase, the multiphase pump 200 may effectively increase the pressure of the wet gas. The wet gas leaving the multiphase pump 200 is directed to the well inlet 20 through line 60 and re-used. Alternatively, if the wet gas contains hydrocarbons, the export line 70 may be opened to deliver the hydrocarbons for sale or other use. If excess wet gas exists, the flare line 65 may be opened to direct wet gas to a flare stack for disposal. In this manner, the wet gas in the return fluid may be recycled, collected, or otherwise disposed.

As shown in Figure 1, the circuit 5 may optionally include a second gas supply 32 connected to the separator 110. The second gas supply 32 may be used as an additional source of gas such as nitrogen. Additionally, the second gas supply may assist with transient fluid flow management common with underbalanced drilling operations.

In another embodiment (not shown), the wet gas leaving the multiphase pump 200 may be directed to a secondary separator. The secondary separator may be used to remove substantially all of the entrained solid and liquid. The separated streams of fluid may then be directed to their respective disposal line. The gas stream leaving the secondary separator will be substantially void of liquid or solid. If desired, another multiphase pump may be used to boost the pressure of the gas stream before it is redirected back to the well inlet 20.

In another embodiment, the export line 70 may alternatively be used as an import line 70. In this respect, the import line 70 may be connected to the wet gas line 60. The import line 70 may be used to supply gas into the wet gas line 60 for introduction into the well 10. In this manner, gas may be added to lighten the drilling fluid from an outside source.

Figure 3 illustrates another embodiment according to the aspects of the present invention. In this embodiment, a second multiphase pump 92 is disposed between the well outlet 15 and the separator 110. One advantage of the second multiphase pump 92 is that it may boost the pressure of the return fluid to facilitate recycling thereof. For example, in some wells, the return fluid leaving the well outlet has very low pressure. The first multiphase pump may not be able to increase the wet gas pressure sufficiently for efficient recycling. In such instances, the second multiphase pump may provide the additional boost needed to recycle the return fluid. In another aspect, the fluid handling circuit 5 may include an optional bypass line 94 to circumvent the second multiphase pump 92 when the return fluid is of sufficient pressure. In another aspect still, the second multiphase pump 92 may be used without the multiphase pump 200. In this instance, the second multiphase pump 92 may be designed to increase the pressure of the wellstream sufficiently so as to result in a desired wet gas pressure leaving the separator 110. Consequently, the wet gas may be recycled or exported without the need of multiphase pump 200.

Although the embodiments described above relates to underbalanced drilling, it must be noted that aspects of the present invention are equally applicable to a well not undergoing underbalanced operations. Rather, it is contemplated that aspects of the present invention are generally applicable to the management of wellbore fluids and

pressures during wellbore operations without relying on fluid weight to achieve such management.

In another aspect, the fluid handling system 400 may be used to handle fluids from a wellbore during well testing. Figure 4 shows a well 410 having a temporary production testing equipment including a production tubing 415 and at least one packer 420 disposed between the wellbore 410 and the production tubing 415. During testing, the well 410 is permitted to flow hydrocarbon for a period of time so that a quantitative analysis may be performed to determine the hydrocarbon reserves of the well 410. In some instances, the well 410 may be permitted to flow for a period of 10 days before the testing is complete.

During production testing, fluid in the wellbore 410 is allowed to move up the tubing 415, exit the well 410, and enter a separator 425. The fluid is a multiphase fluid because it may contain gas, oil, water, or combinations thereof. In the separator 425, the fluid is separated into different streams of oil, water, and gas. It must be noted that each stream may contain a small amount of various phases. For example, the gas stream may contain small amounts of water and oil, and thus, may appropriately be considered a wet gas stream. The wet gas stream leaving the separator 425 is directed to a multiphase pump 430 where its pressure is increased to a level greater than or equal to the pressure in an export line 435. In this manner, the wet gas stream may be captured during well testing. As a result, the aspects of the present invention provide a method and apparatus to handle fluids from the well 410 during well testing without flaring. However, if desired, the fluid handling system 400 may optionally include a flare line 445 connected to the wet gas line 440. The flare line 445 permits flaring of the wet gas stream and adds versatility to the system 400. The separated oil and water leave the separator 425 through lines 450 and 455, respectively.

As shown in the Figure 4, the system 400 may optionally include a second multiphase pump 460 disposed between the well outlet 465 and the separator 425. The second multiphase pump 460 may increase the pressure of the return fluids so the wet gas pressure leaving the separator 425 is greater than or equal to the export

line pressure. The system 400 may also include a bypass line 470 to circumvent the second multiphase pump 460.

While the foregoing is directed to embodiments of the present invention, other and further embodiments of the invention may be devised without departing from the basic scope thereof, and the scope thereof is determined by the claims that follow.

We Claim:

1. A system for handling fluids returning from a well, the well having an inlet and an outlet, comprising:

a separator having an inlet and an outlet, wherein the inlet of the separator is in selective fluid communication with a source of the return fluids; and

at least one multiphase pump in selective fluid communication with the separator.

2. The system as claimed in claim 1, wherein the at least one multiphase pump comprises at least one cylinder having a respective plunger.

3. The system as claimed in claim 2, wherein the at least one multiphase pump comprises a first cylinder and a second cylinder.

4. The system as claimed in claim 3, wherein the respective plungers in the first cylinder and the second cylinder move in alternating cycles.

5. The system as claimed in any of claims 1 to 4, wherein a wet gas is separated from the fluids.

6. The system as claimed in claim 5, wherein the wet gas comprises more than one phase.

7. The system as claimed in any preceding claim, wherein the separator is a four phase separator.

8. The system as claimed in claim 1, wherein a first multiphase pump is connected to the outlet of the separator.

9. The system as claimed in claim 8, wherein a second multiphase pump is disposed between the inlet of the separator and the outlet of the well.

10. The system as claimed in claim 8, wherein a wet gas is delivered to the first multiphase pump.

11. The system as claimed in claim 10, wherein the wet gas is delivered from the first multiphase pump to the well inlet.

12. The system as claimed in claim 10, wherein the wet gas is delivered from the first multiphase pump to an export line.

13. The system as claimed in claim 1, wherein the outlet of the separator is in selective fluid communication with the inlet of the well.

14. The system as claimed in claim 13, wherein a portion of the return fluid is recycled to the well inlet.

15. The system as claimed in claim 14, wherein the recycled portion comprises a wet gas.

16. The system as claimed in claim 15, wherein the wet gas is selected from the group consisting of nitrogen, hydrocarbon, and combinations thereof.

17. The system as claimed in claim 1, wherein the at least one multiphase pump is disposed between the inlet of the separator and the outlet of the well.

18. The system as claimed in claim 17, wherein the return fluids comprise a wet gas.

19. The system as claimed in claim 18, wherein the wet gas is recycled to the well inlet.

20. The system as claimed in any of claims 17 to 19, wherein the at least one multiphase pump comprises at least one cylinder having a respective plunger.

21. The system as claimed in claim 20, wherein the at least one multiphase pump comprises a first cylinder and a second cylinder.

22. The system as claimed in claim 21, wherein the respective plungers in the first cylinder and the second cylinder move in alternating cycles.

23. The system as claimed in claim 1, wherein the well is in an underbalanced state.

24. The system as claimed in claim 23, wherein the at least one multiphase pump comprises at least one cylinder having a respective plunger.

25. The system as claimed in claim 23, wherein the at least one multiphase pump comprises a first cylinder and a second cylinder, wherein the first cylinder and the second cylinder move in alternating cycles.

26. The system as claimed in any of claims 23 to 25, wherein a wet gas is separated from the fluids.

27. The system as claimed in any of claims 23 to 26, wherein the separator is a four phase separator.

28. The system as claimed in claim 26, wherein the wet gas is delivered from the first multiphase pump to the well inlet.

29. The system as claimed in claim 26, wherein the wet gas is delivered from the first multiphase pump to an export line.

30. The system as claimed in claim 23, wherein the at least one multiphase pump is disposed between the inlet of the separator and the outlet of the well.

31. The system as claimed in claim 30, wherein the at least one multiphase pump comprises at least one cylinder having a respective plunger.

32. The system as claimed in claim 31, wherein the at least one multiphase pump comprises a first cylinder and a second cylinder.

33. The system as claimed in claim 32, wherein the respective plungers in the first cylinder and the second cylinder move in alternating cycles.

34. A method of handling fluids returning from a well, comprising:
introducing the fluids into a separator; and
introducing at least a portion of the fluids into at least one multiphase pump.

35. The method as claimed in claim 34, further comprising separating a wet gas from the fluids.

36. The method as claimed in claim 35, further comprising recycling the wet gas.

37. The method as claimed in claim 35 or 36, wherein the wet gas comprises one or more phases.

38. The method as claimed in claim 35, further comprising delivering the wet gas to an export line.

39. The method as claimed in any of claims 34 to 38, wherein the at least one multiphase pump comprises at least one cylinder having a respective plunger.

40. The method as claimed in claim 39, wherein the at least one multiphase pump comprises a first cylinder and a second cylinder.

41. The method as claimed in claim 40, wherein the respective plungers in the first cylinder and the second cylinder move in alternating cycles.

42. The method as claimed in any of claims 34 to 38, wherein the at least one multiphase pump comprises a first cylinder and a second cylinder, wherein the first cylinder and the second cylinder move in alternating cycles.

43. The method as claimed in claim 34, wherein the well is undergoing underbalanced operations.

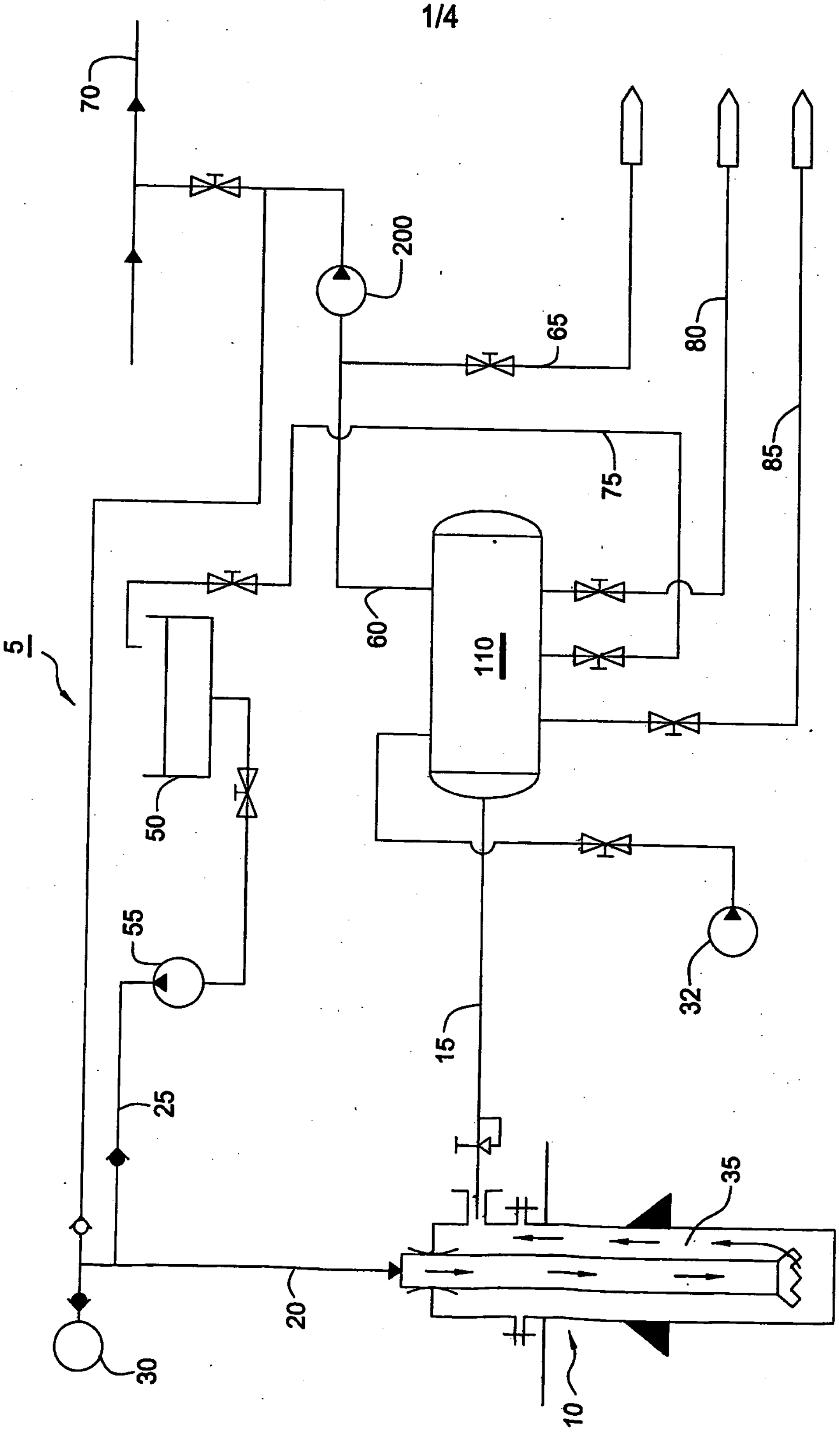

FIG. 1

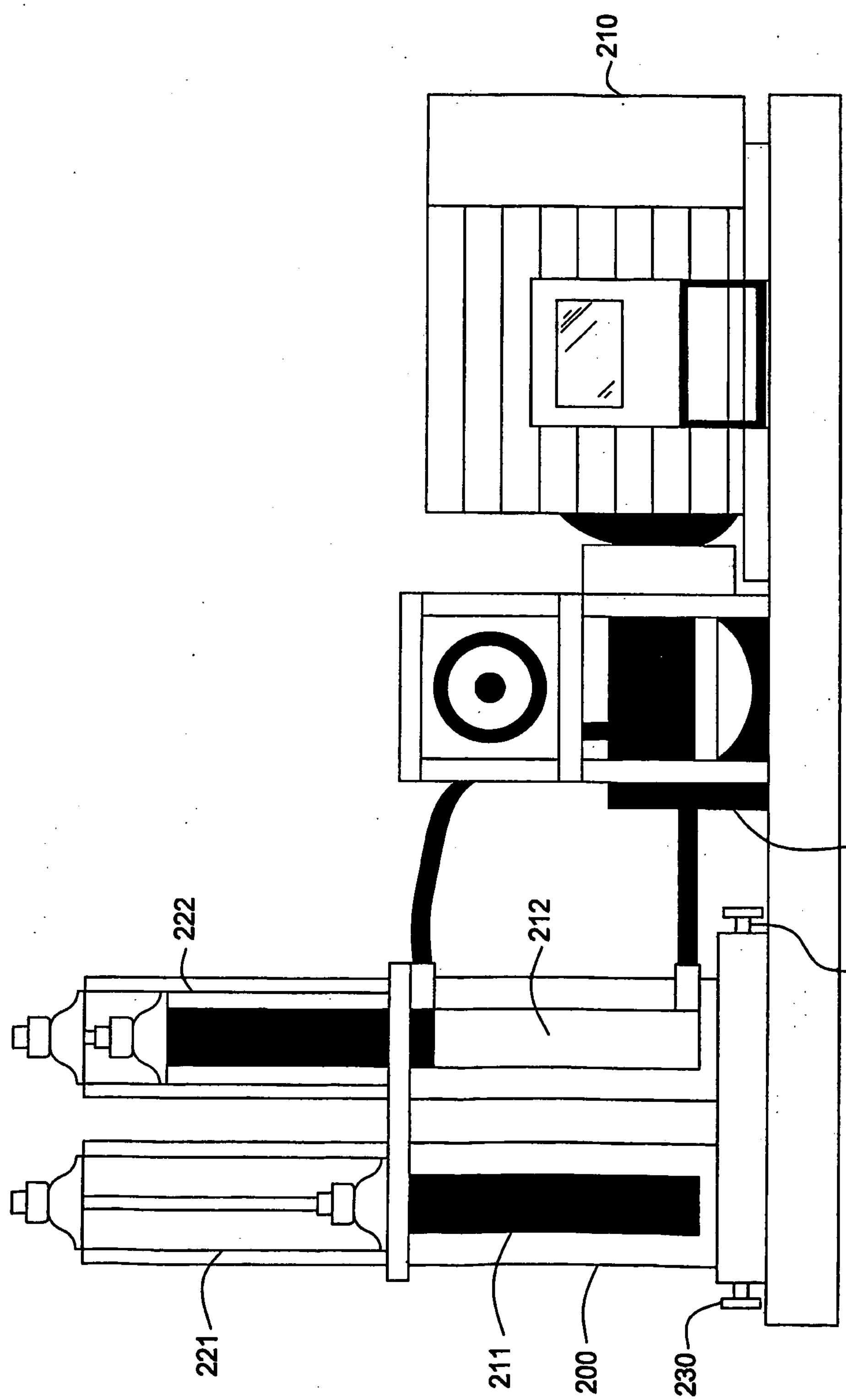

FIG. 2

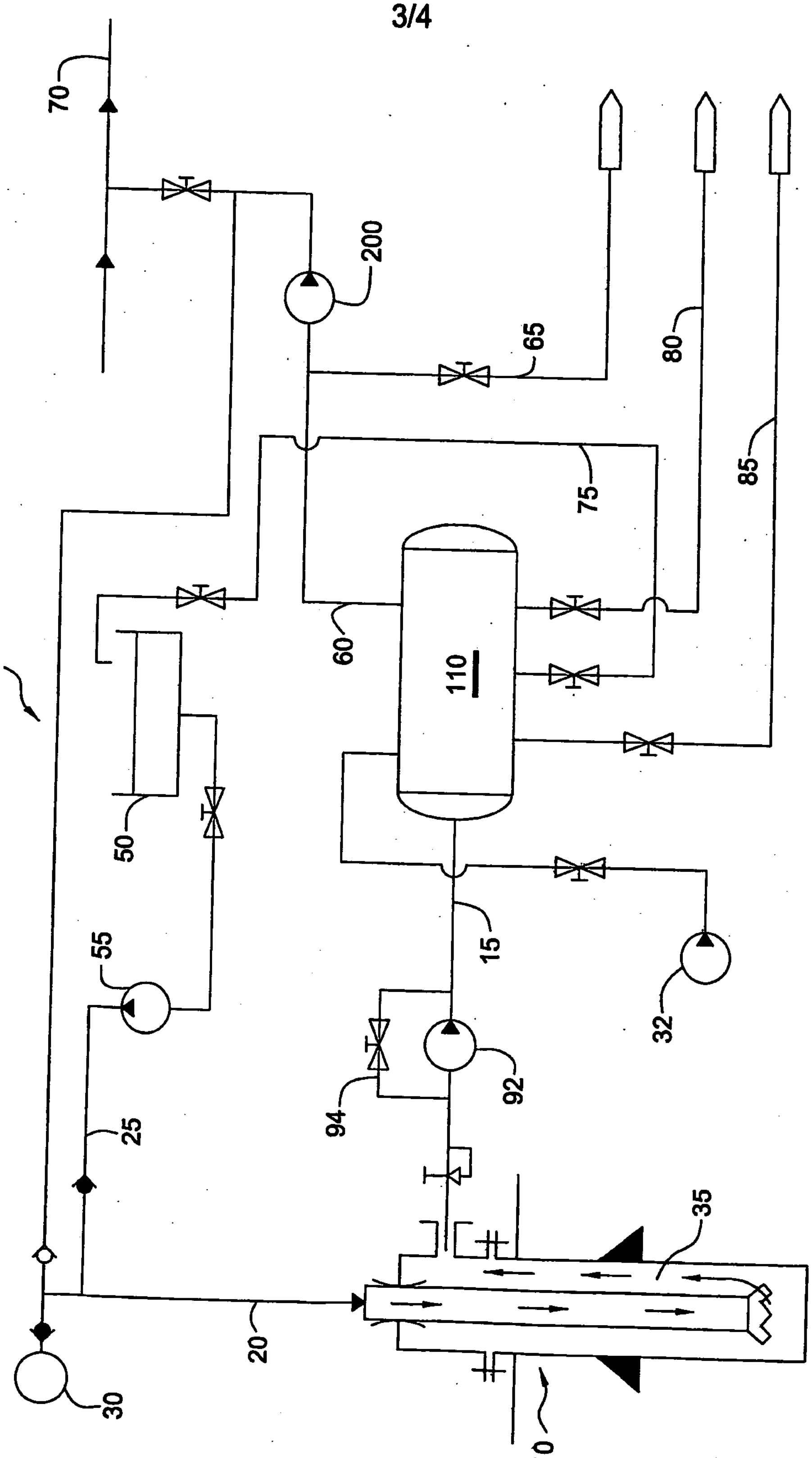

FIG. 3

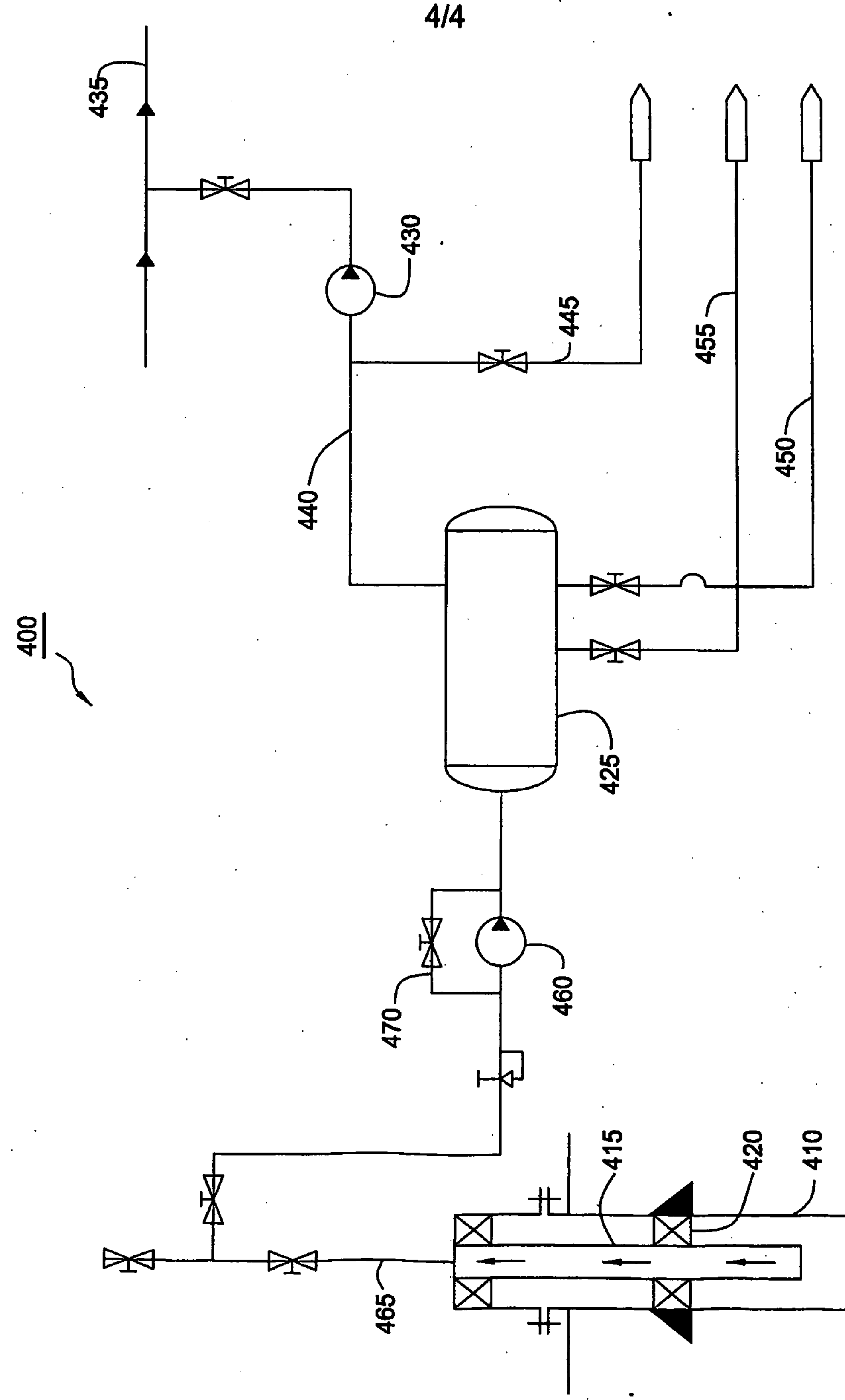

FIG. 4

INTERNATIONAL SEARCH REPORT

International Application No
PCT/US 03/21487

A. CLASSIFICATION OF SUBJECT MATTER
IPC 7 E21B43/12 E21B43/34 E21B43/40

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)
IPC 7 E21B F04B

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practical, search terms used)

EPO-Internal

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category °	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
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X	GB 2 215 408 A (SHELL INT RESEARCH) 20 September 1989 (1989-09-20)	1,5,6, 13-19, 23,26, 28,30, 34-37
Y	page 4, line 29 -page 5, line 33; figure 2	2,39
X	WO 01 83947 A (TVEIT EGIL ;KONGSBERG OFFSHORE AS (NO); SANDERFORD MORTEN (NO); FR) 8 November 2001 (2001-11-08)	1,5,6,8, 23,26, 34-37
Y	page 8, line 3 -page 9, line 9; figure 1	2,39

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[X] Further documents are listed in the continuation of box C.

[X] Patent family members are listed in annex.

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"Y" document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art.

"&" document member of the same patent family

Date of the actual completion of the international search	Date of mailing of the international search report
5 November 2003	14/11/2003

Name and mailing address of the ISA	Authorized officer
European Patent Office, P.B. 5818 Patentlaan 2 NL – 2280 HV Rijswijk Tel. (+31-70) 340-2040, Tx. 31 651 epo nl, Fax: (+31-70) 340-3016	Ott, S

INTERNATIONAL SEARCH REPORT

International Application No
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C.(Continuation) DOCUMENTS CONSIDERED TO BE RELEVANT

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Information on patent family members

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